Evolutie in het leveren van ruimtelijke en temporele water gerelateerde informatie uit satellietbeelden

Arnold G. Dekker

FEWS User Day, Deltares, Delft 5 Juni 2018

Sat Dek pty ltd & CSIRO & Geoscience Australia

INHOUD

- INTRODUCTIE WATERKWALITEIT & KWANTITEIT MBV AARDOBSERVATIE
- AARDOBSERVATIE DATA CUBE(S)-DEMOCRATISERING VAN INFORMATIE
- DUURZAME ONTWIKKELING DOELEN VN (SUSTAINABLE DEVELOPMENT GOALS)
- SAMENVATTING

NL EXPERTISE IN AARDOBSERVATIE VAN WATERKWALITEIT

EXPERTISE BESTAAT BIJ:

- NIOZ: AO, IN SITU METINGEN; KUSTWATEREN EN OCEANEN
- VU: AO VAN BINNEN EN KUSTWATEREN EN CITIZEN SCIENCE
- DELTARES: AO BINNEN EN KUSTWATEREN , MODELLERING, DATA ASSIMILATIE ETC
- WATER INSIGHT BV: GEAUTOMATISEERDE IN SITU METINGEN EN AO VAN BINNEN EN KUSTWATEREN

WHAT DO MANAGERS NEED FROM OPTICAL REMOTE SENSING IN AQUATIC ECOSYSTEMS?

- STATUS, CONDITION AND TREND & ANOMALIES:
  - STATUS (SURVEY, CLASSIFY AND MAP)
    - WHAT IS WHERE? (=99%OF CURRENT REMOTE SENSING EFFORT)
      - (IS IT ABSENT WHEN IT SHOULD BE PRESENT) OR
      - (IS IT PRESENT WHEN IT SHOULD BE ABSENT?)
  - CONDITION:
    - IS IT HEALTHY?, IS IT STABLE?
    - IS IT STRESSED?
  - TREND:
    - IS IT GETTING WORSE OR IS IT IMPROVING?
      - REMOTE SENSING CAN DO HIND CASTING AND NOW CASTING
      - MODEL DATA FUSION AND DATA ASSIMILATION NEEDED FOR FORECASTING
  - ANOMALIES:
    - NORMAL (TO BE EXPECTED) OR EXCEPTIONAL (INDICATING EXCEPTIONAL CHANGE FROM BEFORE? E.G. CLIMATE CHANGE INDICATION?)

VARIABLES THAT CAN BE MEASURED DIRECTLY USING EO IN AQUATIC ECOSYSTEMS (1A)

- WATER COLUMN PROPERTIES:
  - **CHLOROPHYLL-A, PHAEOPHYTIN (ALL PHOTOSYNTHESIZING ORGS)**
  - **CYANOPHYCOCYANIN & CP-ERYTHRIN=>CYANOBACTERIA**
  - **TOTAL SUSPENDED MATTER**
  - **COLOURED DISSOLVED ORGANIC MATTER**
  - **TRANSPARENCY/TURBIDITY/VERTICAL ATTENUATION OF LIGHT**
- 3-D INFORMATION (IF THE BOTTOM IS VISIBLE)
  - **BATHYMETRY (DEPTH OF SUBSTRATE)**
  - **BOTTOM RELIEF (TOPOGRAPHY)**

MORE ADVANCED VARIABLES THAT CAN (SOON) BE MEASURED DIRECTLY USING EO IN AQUATIC ECOSYSTEMS (1B)

- WATER COLUMN PROPERTIES:
  - **PHYTOPLANKTON FUNCTIONAL TYPES**
  - **PARTICLE SIZE DISTRIBUTIONS**

Variables that can be measured directly using EO in aquatic ecosystems (2) *(including object-based image analysis)*

- BENTHIC SUBSTRATUM
  - COASTAL: SEAGRASSES, MACRO-ALGAE AND ASSOCIATED SUBSTRATES & FRESHWATER: MACROPHYTES AND ASSOCIATED SUBSTRATES
    - EXTENT
    - MAIN SPECIES DIFFERENTIATION: *IF SPECTRALLY & SPATIALLY DISCRIMINABLE!*
    - DENSITY OF COVER; BIOMASS
  - CORAL REEF AND ASSOCIATED SUBSTRATES
    - EXTENT
    - BLEACHING
    - MAIN SUBSTRATUM TYPES (LIVE CORAL ,DEAD CORAL , SEAGRASSES, MACRO-ALGAE)-MAIN SPECIES : *IF SPECTRALLY & SPATIALLY DISCRIMINABLE!*

Variables that can be measured directly using EO in supra-to intertidal ecosystems (3) *(including object-based image analysis)*

INTERTIDAL ROCK PLATFORMS AND BEACHES AND MUDFLATS

- : SEAGRASSES, MACRO-ALGAE, BENTHIC MICRO-ALGAE AND ASSOCIATED SUBSTRATES & FRESHWATER: MACROPHYTES AND ASSOCIATED SUBSTRATES
  - EXTENT
  - MAIN SPECIES DIFFERENTIATION: *IF SPECTRALLY & SPATIALLY DISCRIMINABLE!*
  - DENSITY OF COVER; BIOMASS
- INTER TO SUPRATIDAL: SALTMARSH, MANGROVES, FLOODPLAINS
  - EXTENT
  - MAIN SPECIES DIFFERENTIATION: *IF SPECTRALLY & SPATIALLY DISCRIMINABLE!*
  - DENSITY OF COVER; BIOMASS

TOWARDS AN AQUATIC ECOSYSTEMS EARTH OBSERVATION SYSTEM:

& PROVISION OF KEY ENVIRONMENTAL DATA RECORDS (SINCE EARLY 1980'S BY RETROSPECTIVE PROCESSING) WHERE THEY CURRENTLY DO NOT EXIST.

- **SHORELINE EROSION AND FLOODING**
  - SUPRATIDAL (FROM THE MANGROVE AND SALTMARSH VIA THE INTERTIDAL TO THE SUBTIDAL)
  - INTERTIDAL ZONE EXTENT (HAT TO LAT)
  - BATHYMETRY
- **EMERGENCY MANAGEMENT**
  - OIL & CHEMICAL SPILL RESPONSE ATLAS
  - FLOODS
- **EROSION BUDGETS**
  - EFFECT OF LAND-USE CHANGES ON RUN-OFF
- **EUTROPHICATION- NUTRIENTS FLUXES & BUDGETS**
  - INLAND WATERS, BAYS AND ESTUARIES TO CORAL REEFS
  - BATHYMETRY, HABITAT, WATER QUALITY
- **CARBON FLUXES & BUDGETS**
  - LAND TO SEA FLUXES AND RESERVOIRS (COASTAL WETLANDS)
  - HYDRODYNAMICS, SALINITY TRACER
- **NATIONAL ENVIRONMENTAL ACCOUNTS**
  - HABITATS, STATE OF ENVIRONMENT REPORTING

https://www.eomap.com/world-water-quality/

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About EOMAP

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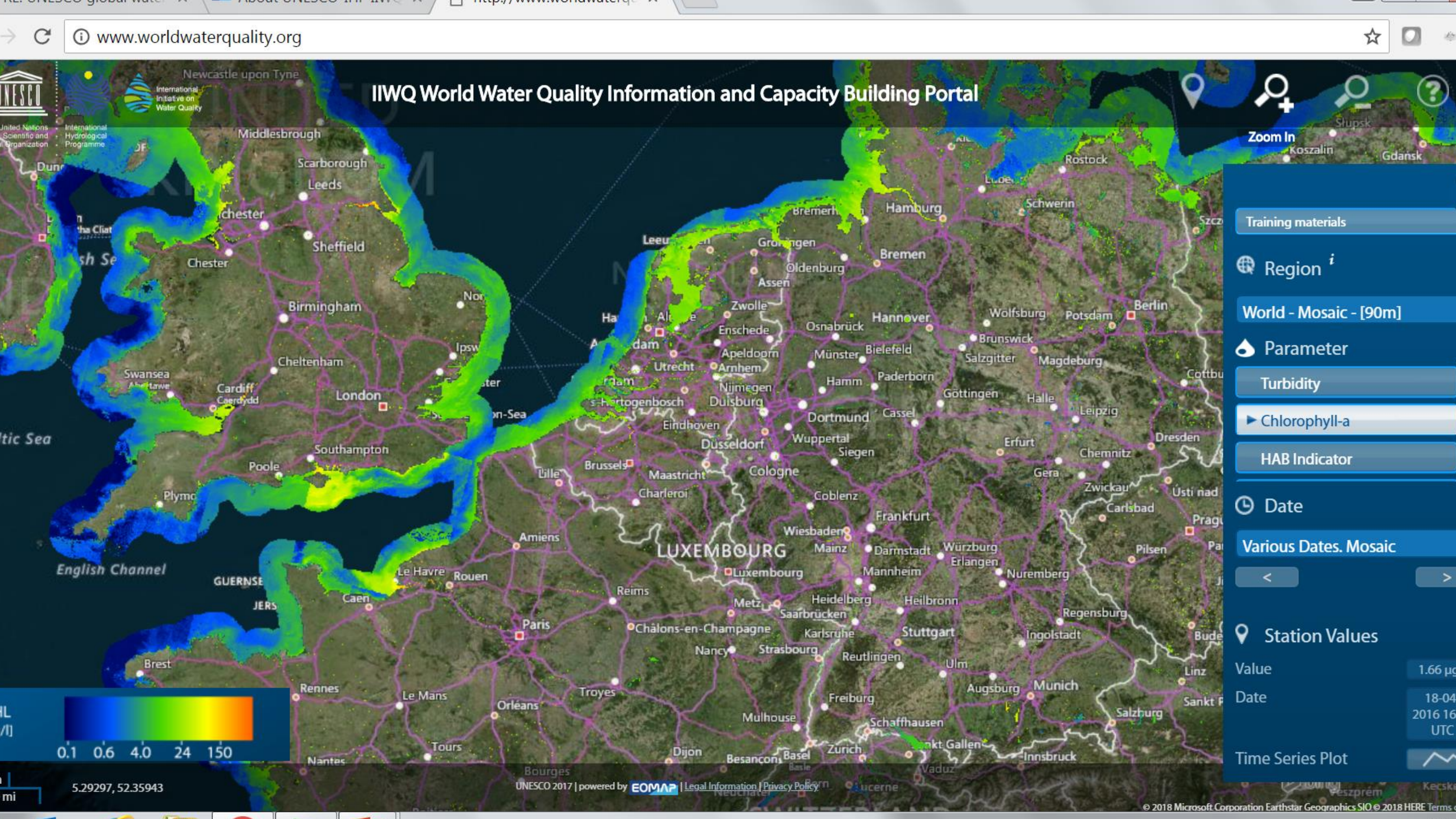
UNESCO-IHP IIWQ World Water Quality Portal

World's first global water quality portal built to support UNESCO Program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International Hydrological Programme
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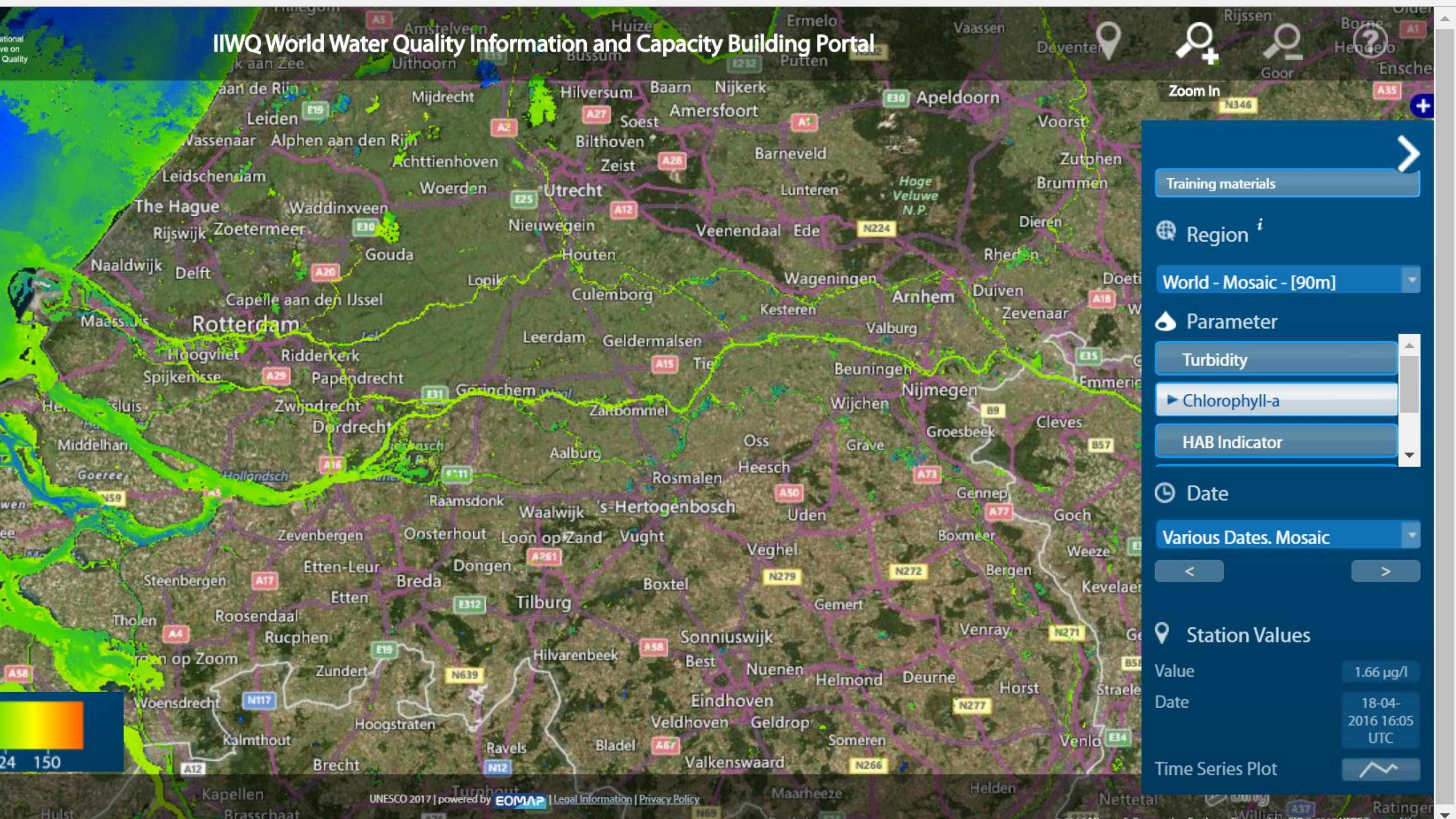
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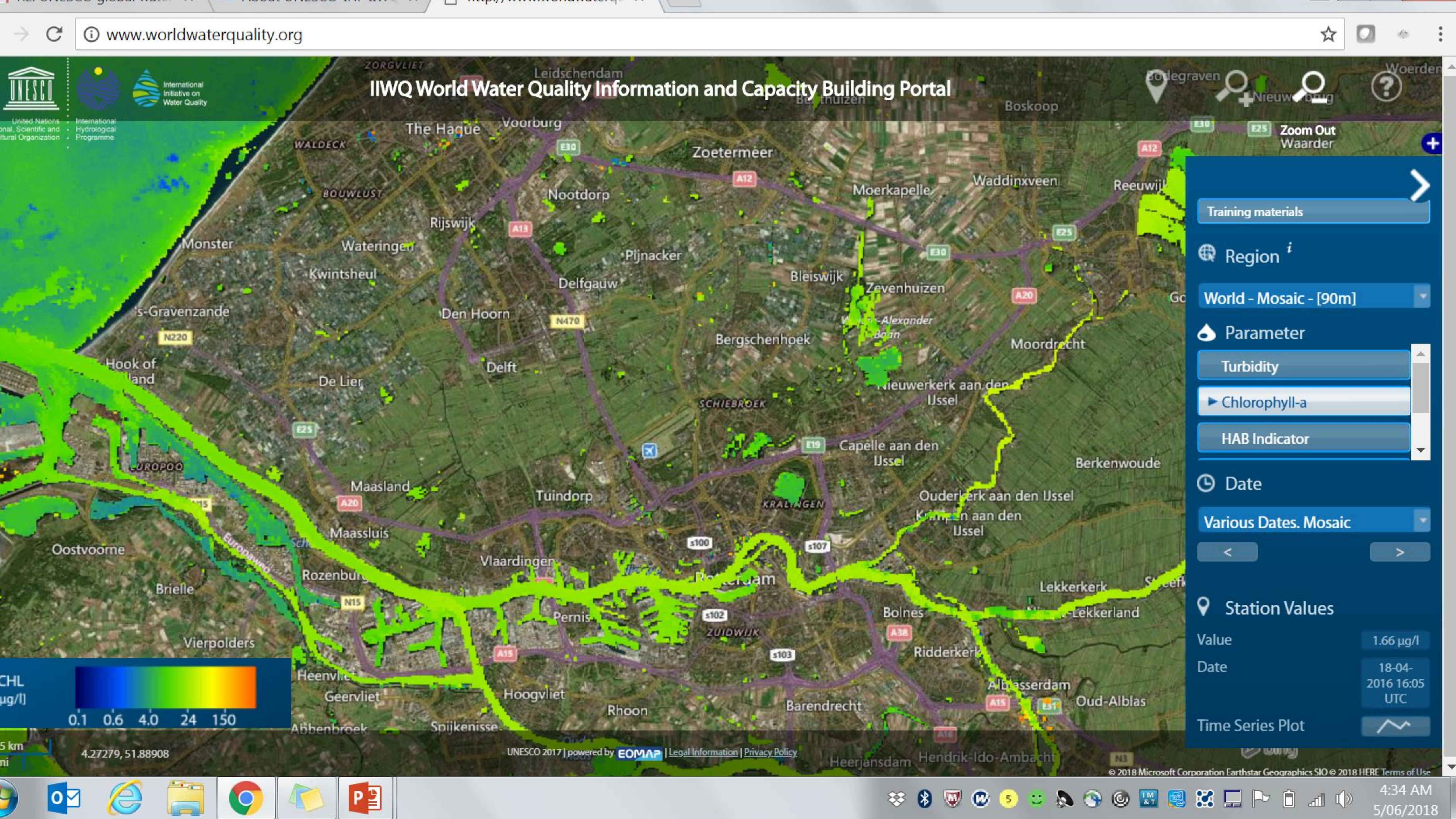
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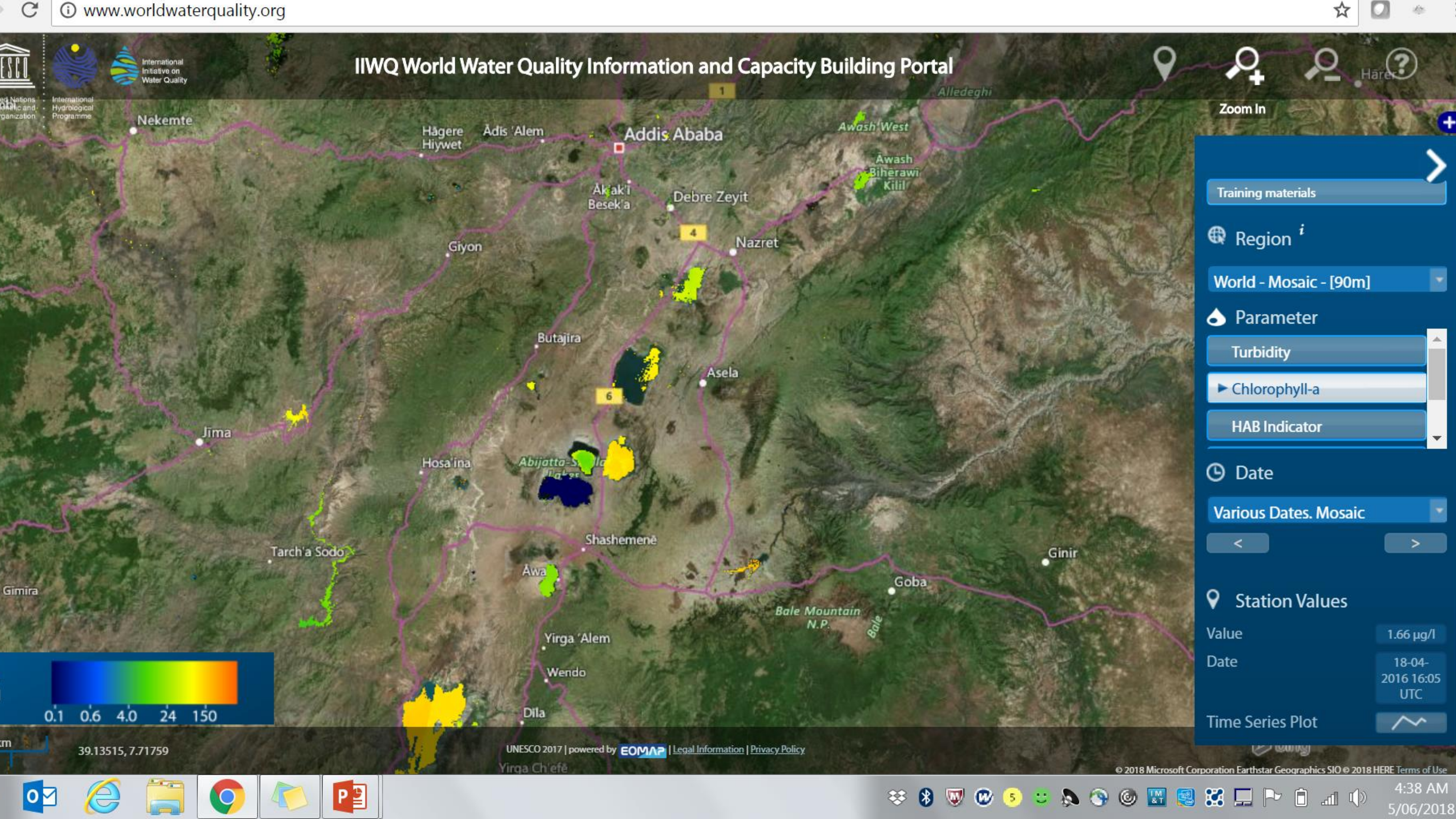

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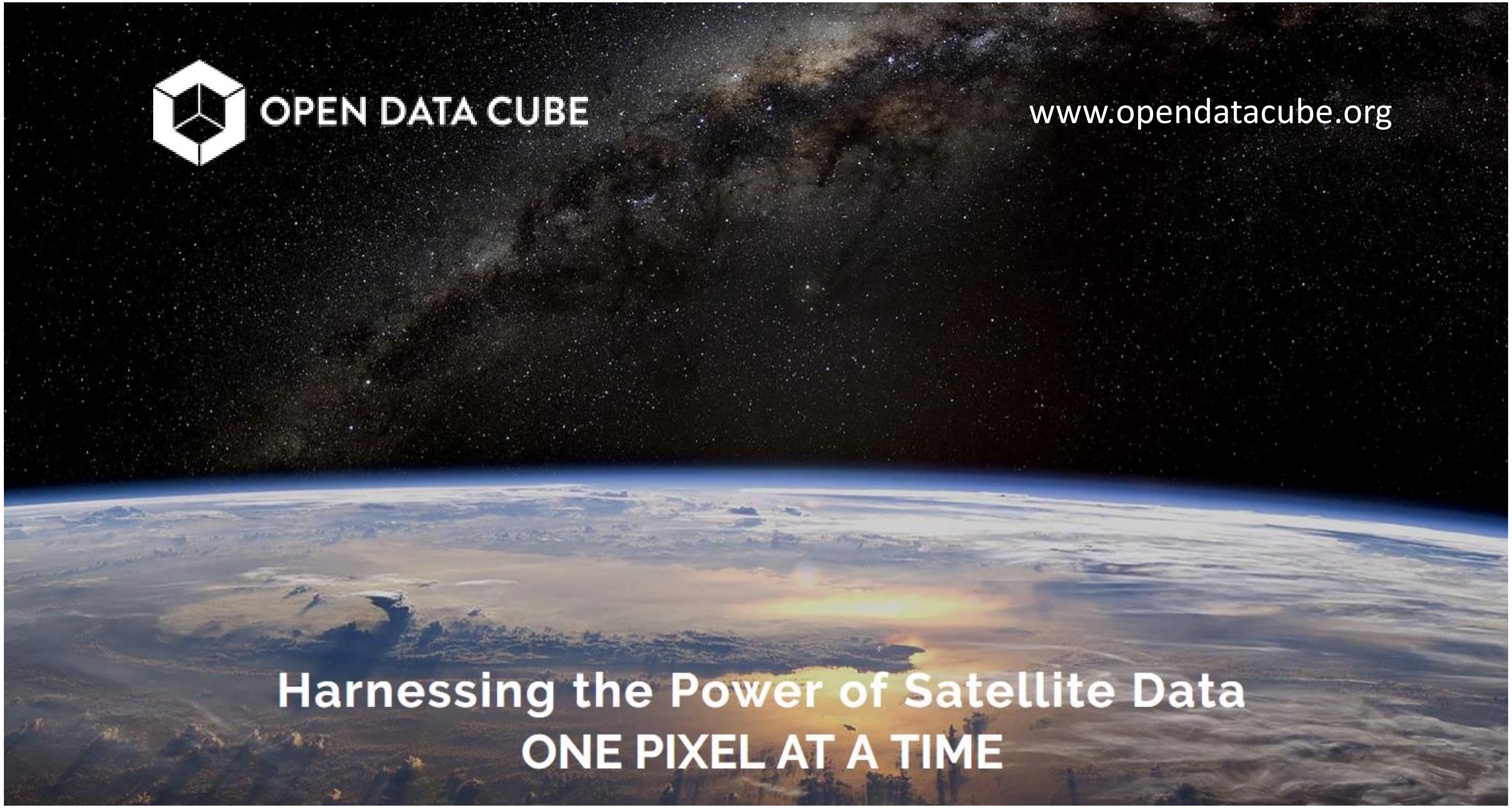
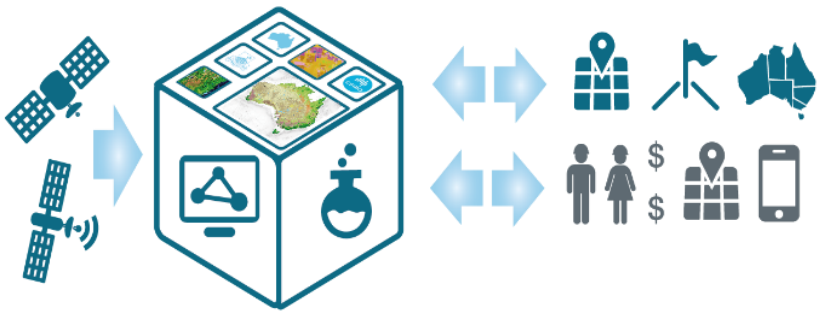

OPEN DATA CUBE
www.opendatacube.org
Harnessing the Power of Satellite Data
ONE PIXEL AT A TIME

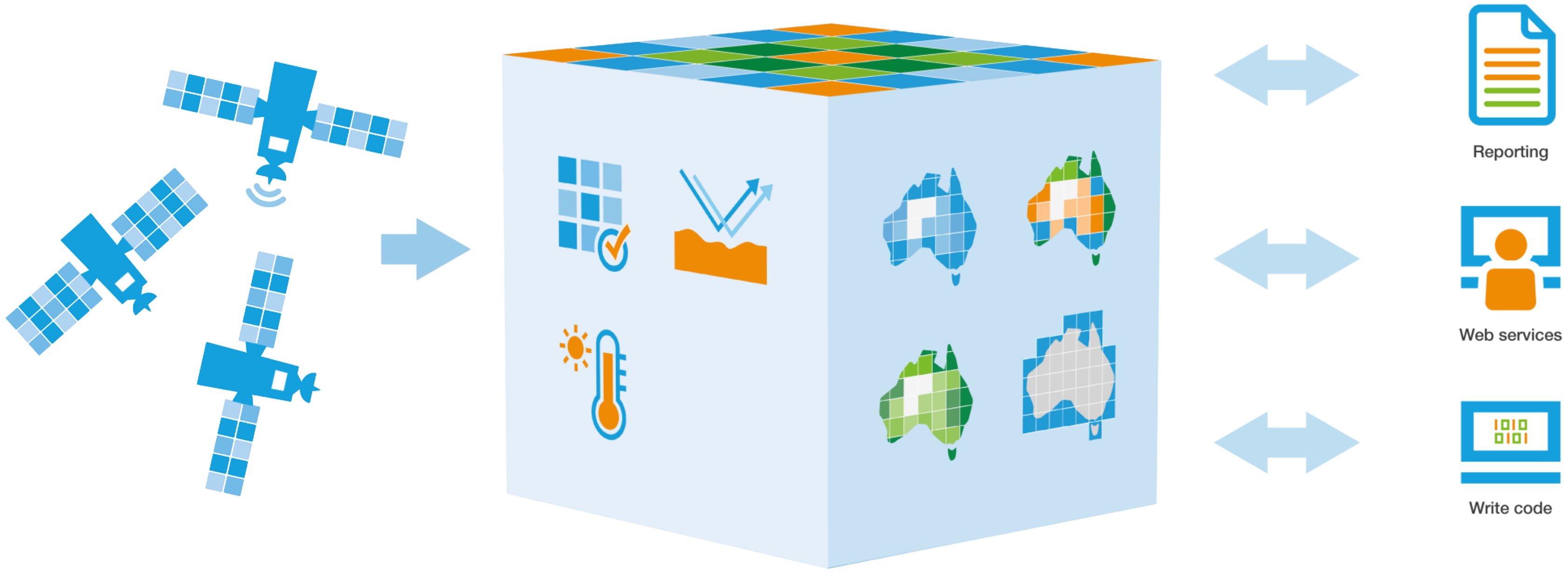
Open Data Cube: A petabyte-scale EO Science Platform

Before: Individuals invest in entire value chain

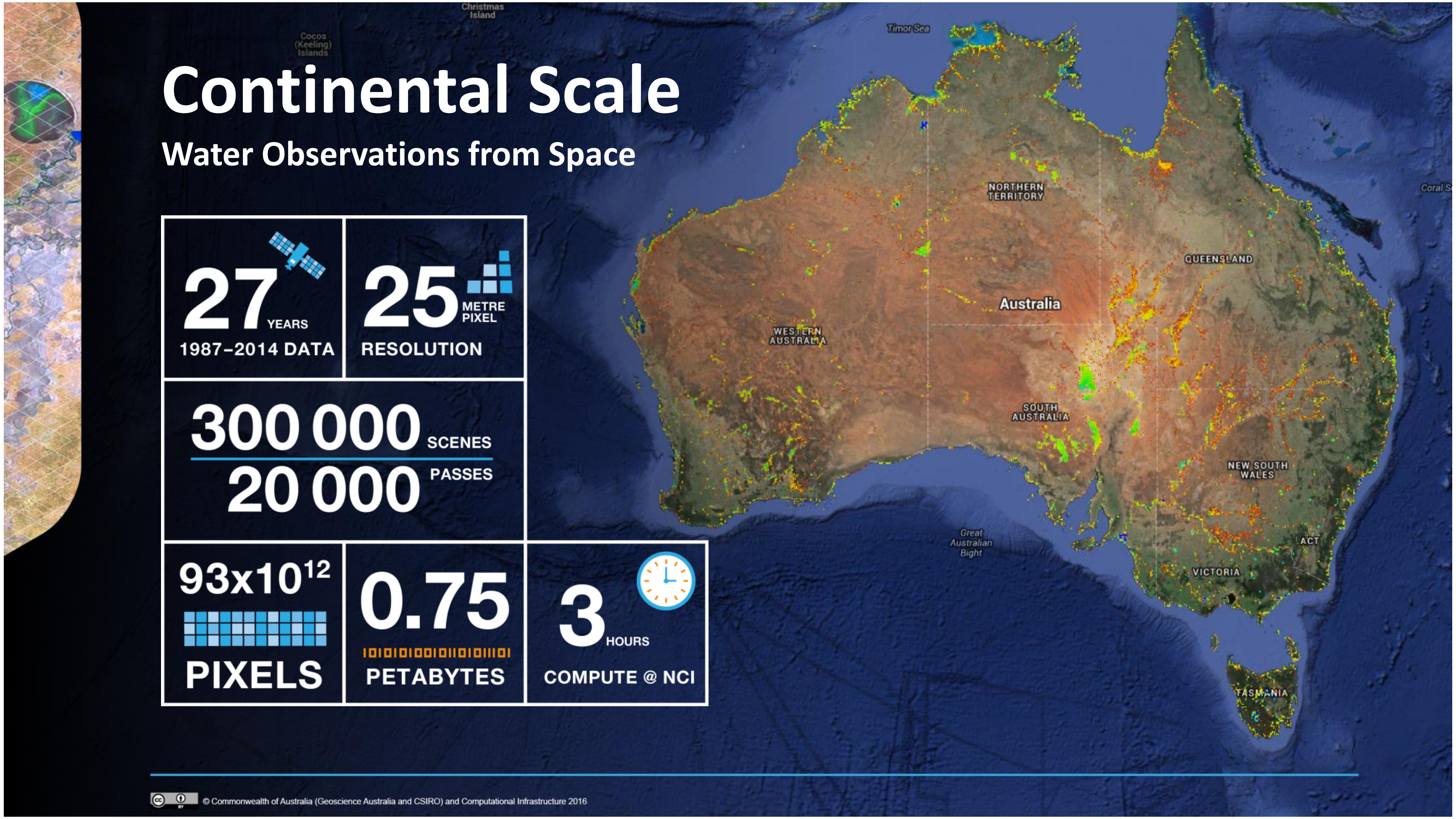
After: Data supply and big data analysis platform is shared – individuals focus on delivery of specific value



What is DataCube?

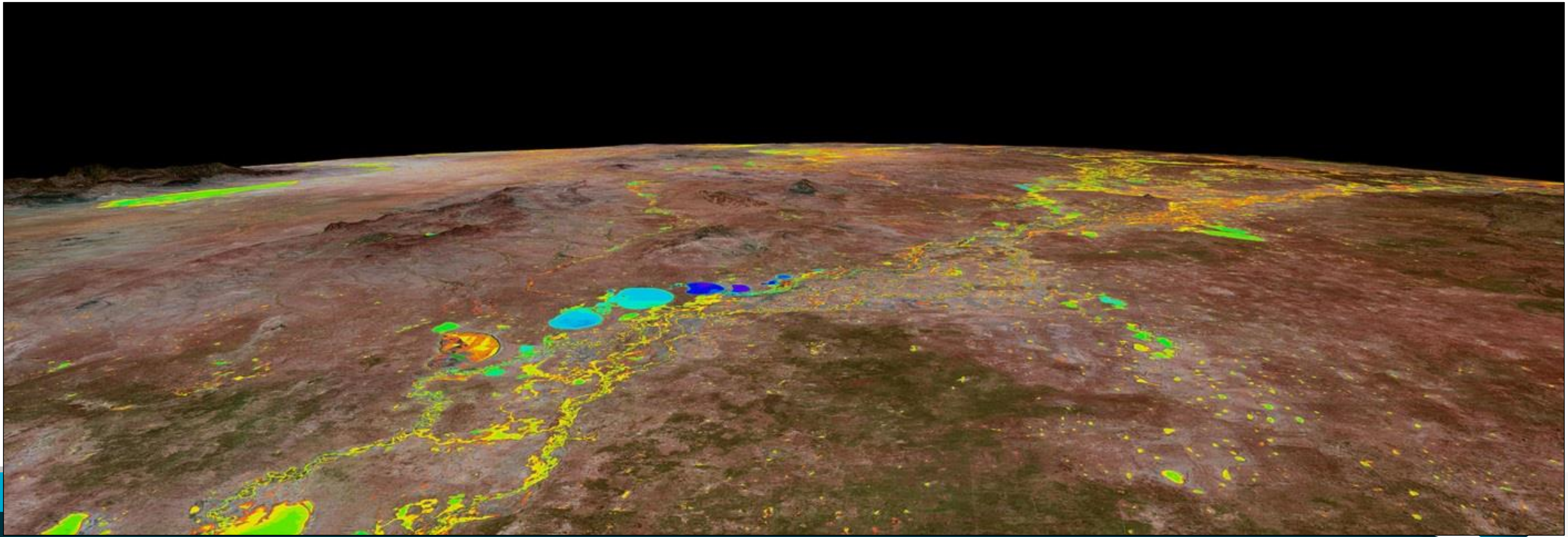


Open Source, Multi-sensor, space-to-ground data integration & modelling platform on high performance supercomputers and/or clouds.

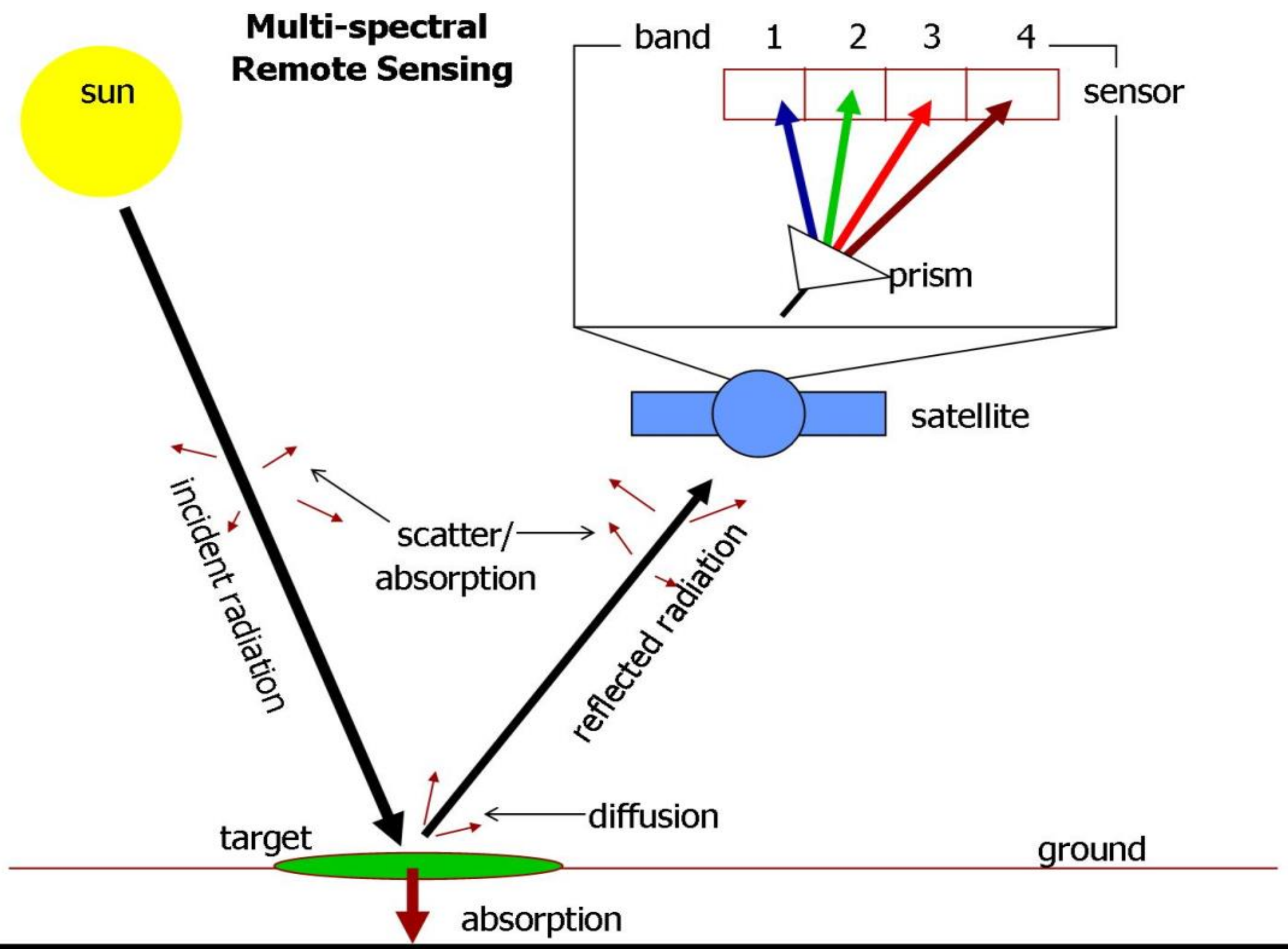


Continental Scale
Water Observations from Space
27 YEARS
1987–2014 DATA
25 METRE PIXEL
RESOLUTION
300 000 SCENES
20 000 PASSES
93x10^12
PIXELS
0.75
PETABYTES
3 HOURS
COMPUTE @ NCI
Christmas Island
Cocos (Keeling) Islands
Timor Sea
NORTHERN TERRITORY
QUEENSLAND
Australia
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
ACT
VICTORIA
TASMANIA
Great Australian Bight
© Commonwealth of Australia (Geoscience Australia and CSIRO) and Computational Infrastructure 2016

Water Observations from Space: frequency of inundation over 30 years based on Earth Observation data: Part of the National Flood Risk Information Project (2011→)

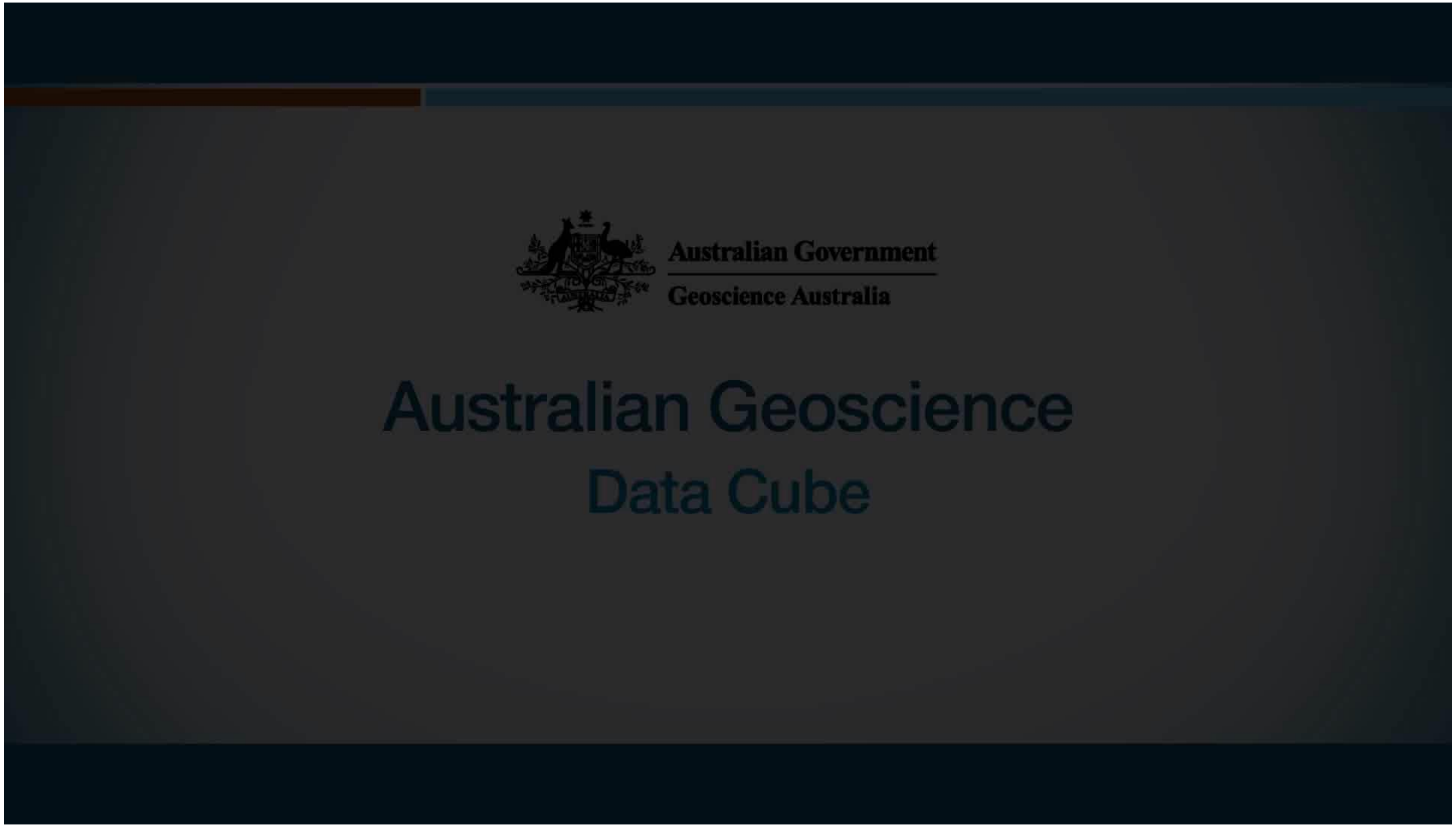


How do Satellites "See" Water?



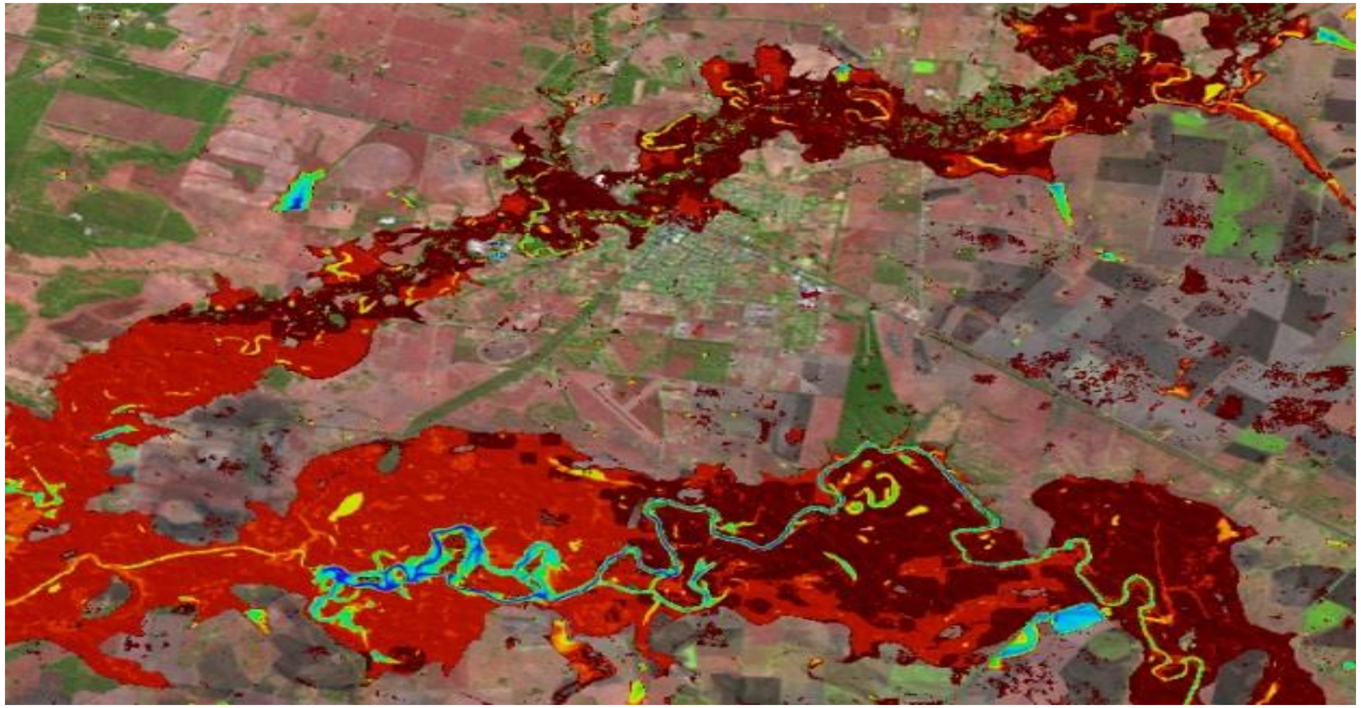
- Optical satellites measure the amount of sunlight reflected from the earth.
- Different objects (targets) reflect light differently, giving us the ability to identify what the satellite is seeing from the measured light.
- Water absorbs certain parts of the spectrum that we can't see with the eye. We can use this as a water "signature".

From Satellite to Water using The Data Cube

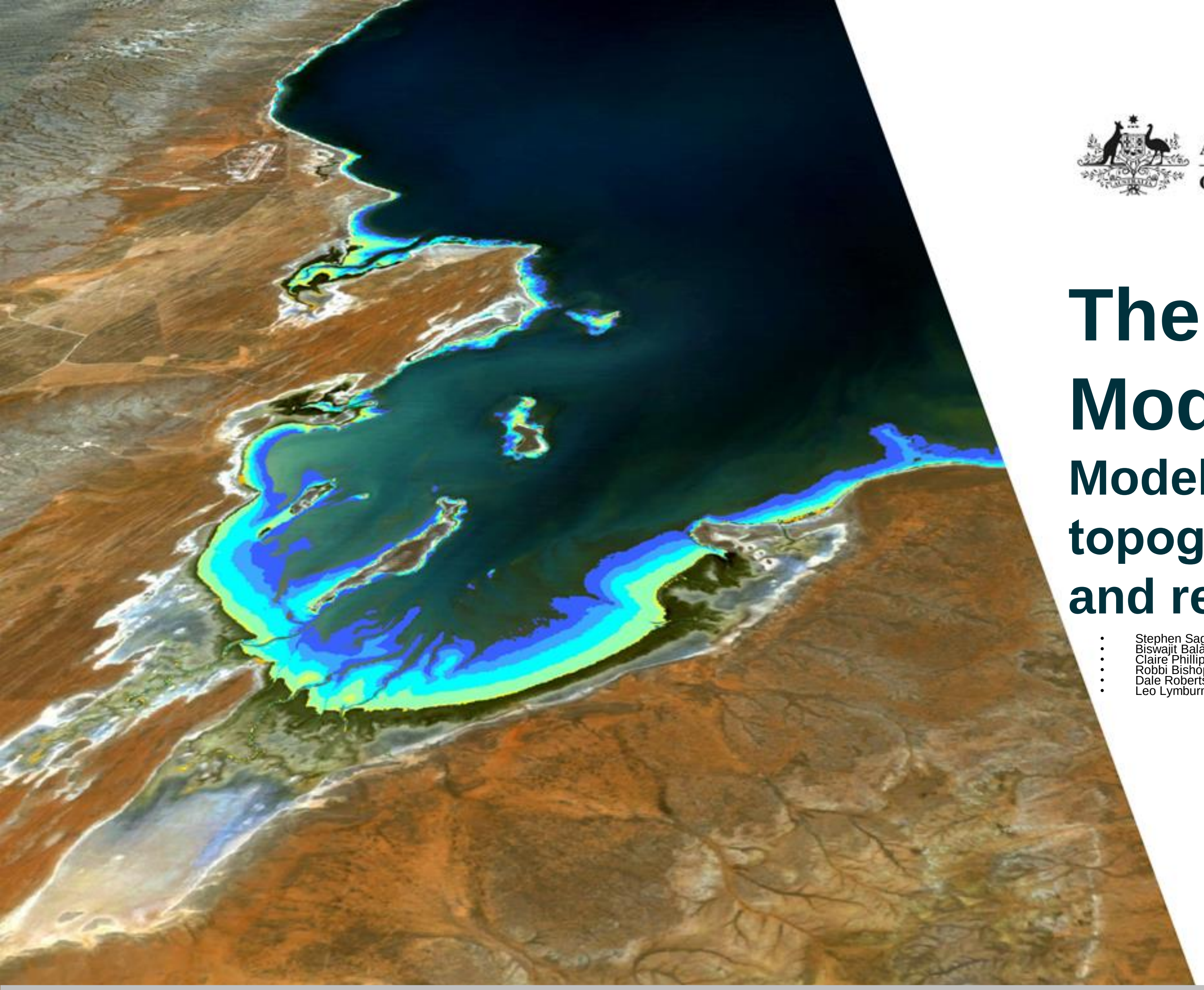


Applications of WOfS: Flood Mapping

By comparing the area of water that is observed frequently, with the area that is observed rarely, we can understand where permanent water occurs and how the area changes during flood.



Chinchilla in southern Queensland, showing permanent water in blue colours and flooding in reds colours. The red areas spread across the floodplains around the permanent water and extend into the Chinchilla township.



The Intertidal Extents Model (ITEM) v2.0 –

Modelling the intertidal extent and topography of Australia's coastline and reefs

- Stephen Sagar
- Biswajit Bala
- Claire Phillips
- Robbi Bishop-Taylor
- Dale Roberts
- Leo Lymburner

Why do we want to map the intertidal zone?

- An important coastal ecosystem, characterised by high productivity and biodiversity and providing habitat for migratory shorebirds worldwide

- Provides critical coastal protection from extreme storm events, and is often a component of the coastal geomorphologic system around high value commercial asset sites such as ports.

- Capturing information on the extent and topography of the intertidal zone, particularly at a continental scale, is a challenging and costly exercise.

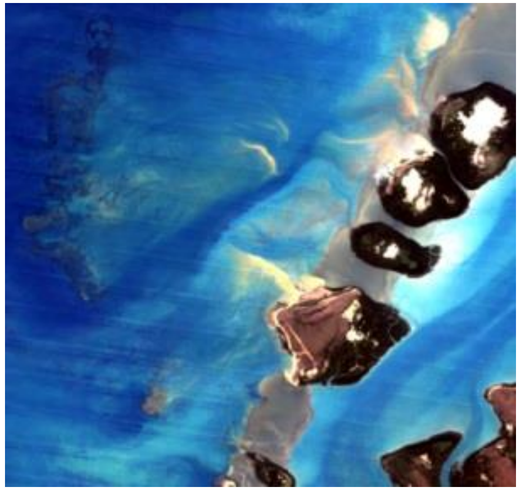
- The physical environment makes traditional surveying methods difficult to implement, and acquisition of airborne elevation data (LiDAR etc) is expensive and subject to tidal regimes of the study site.

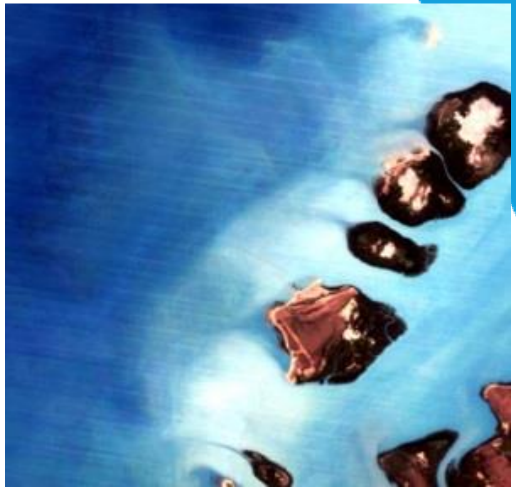
Remote sensing is a cost effective option, but still subject to tidal regimes and environmental factors. Recent single image analysis (*Dhanjal-Adams et al., 2016*) has estimated Australia's tidal flats at a **minimum area of 9,855km^2**

CSIRO


1987

The Intertidal Extents Model (ITEM) Process



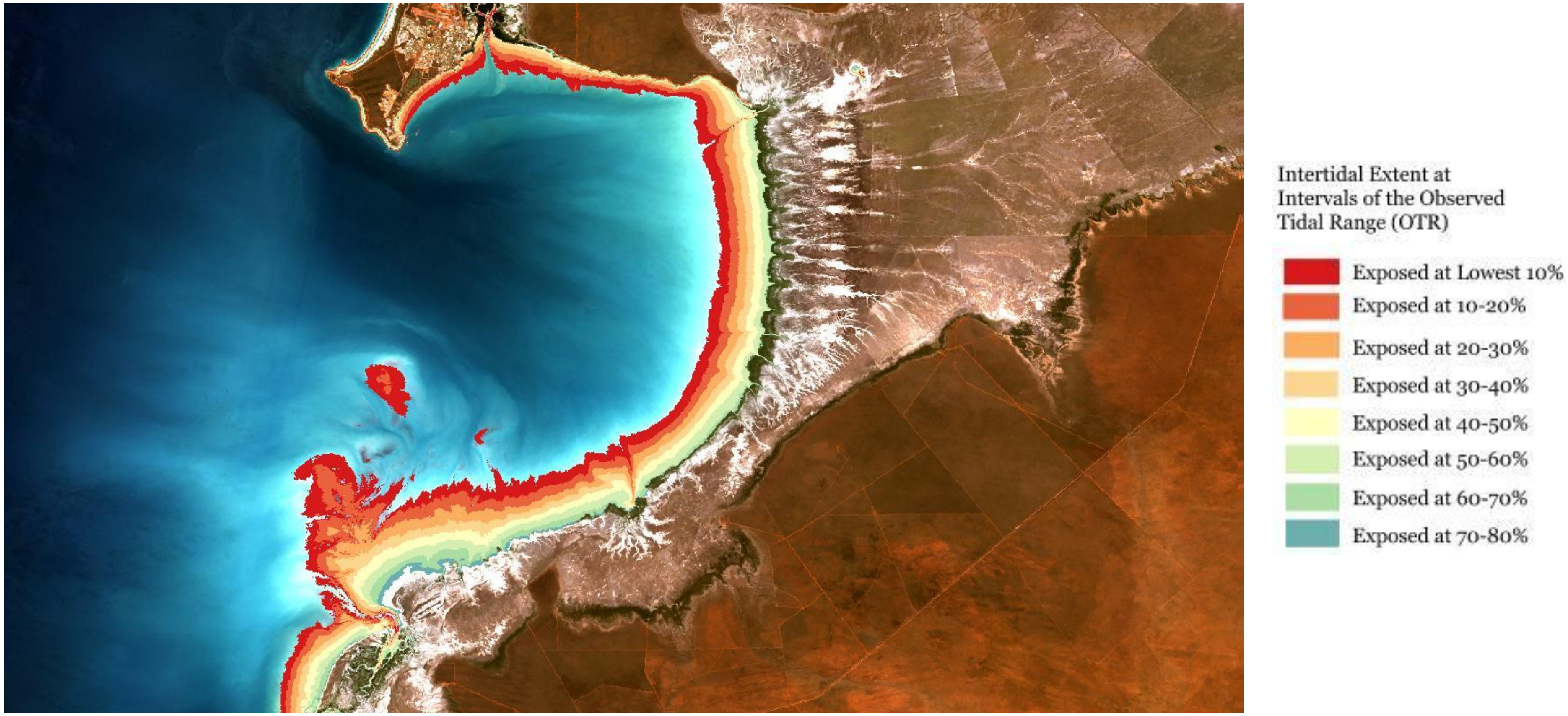


Lowest Observed Tide (LOT)

Highest Observed Tide (HOT)

- The Observed Tidal Range is divided into 10 equal interval buckets to create ensemble stacks of observations for each 10% of the range
- Each tile stack of observations is attributed with a tidal height utilising the OTPS model
- Observations are the reordered based on tidal height rather than time

The Relative Extents Model

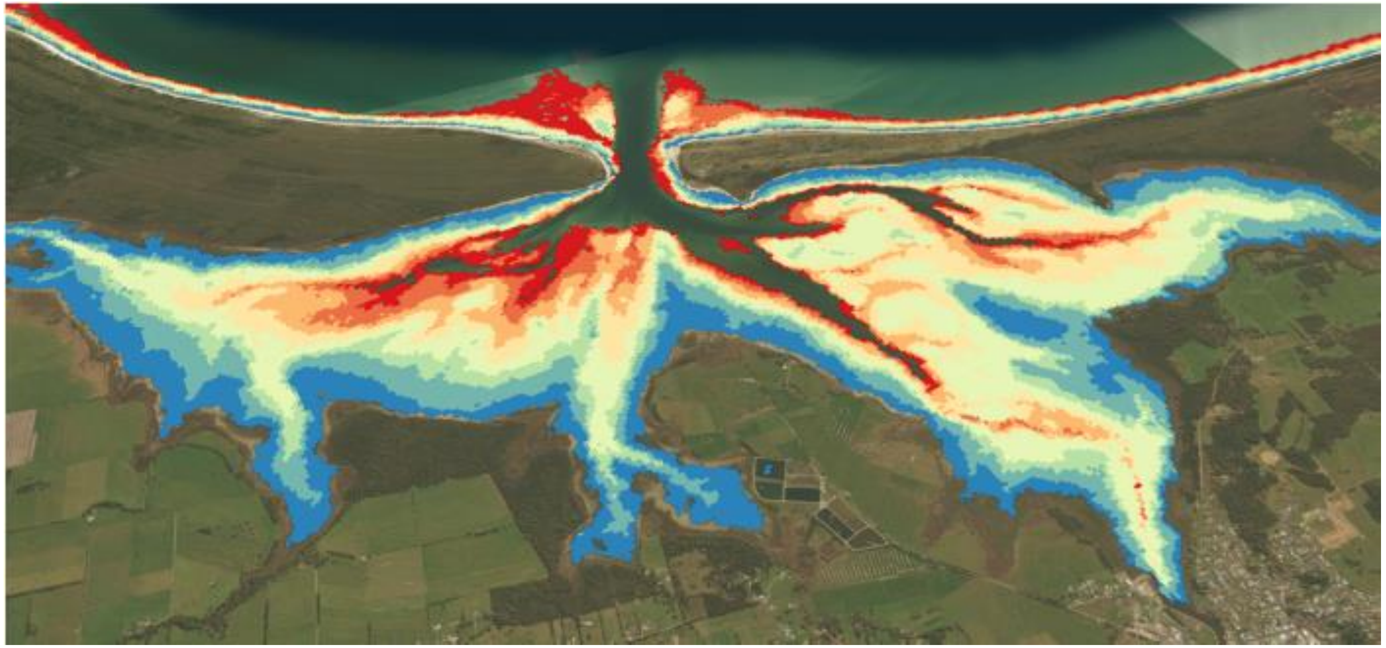


Roebuck Bay, Western Australia

Models the Extent and Topography of the Intertidal Flats

Layers values reflect the spatial extent of the exposed intertidal land surfaces at intervals of the OTR

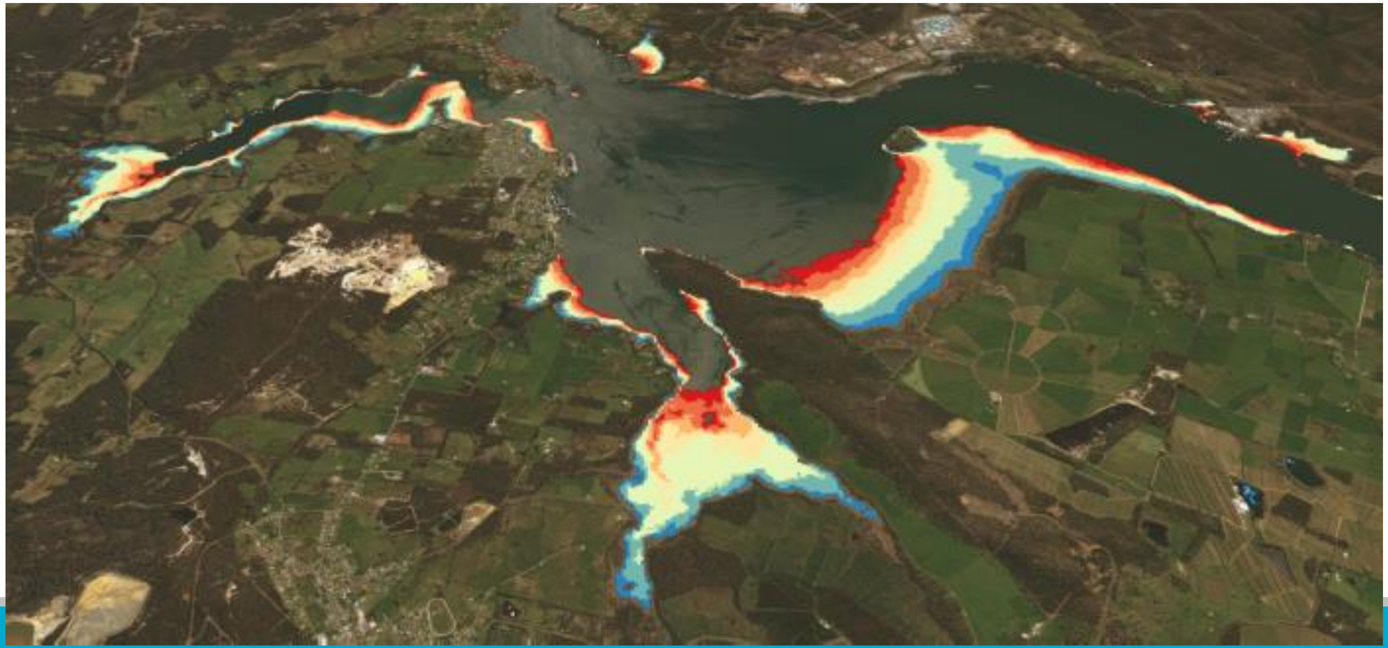
Modelled up to the highest 80% of the OTR



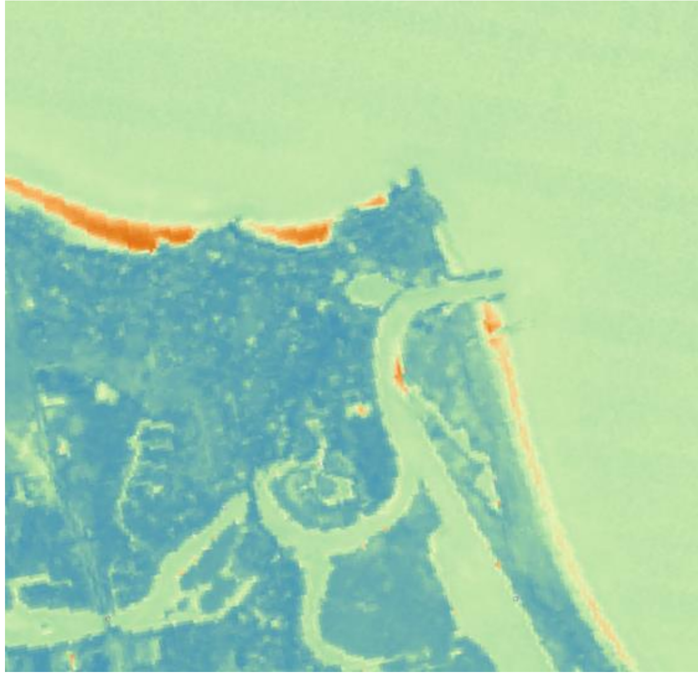
Duck Bay, Tas.

Extent of Exposed Intertidal Region
(% of the Observed Tidal Range)

- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%



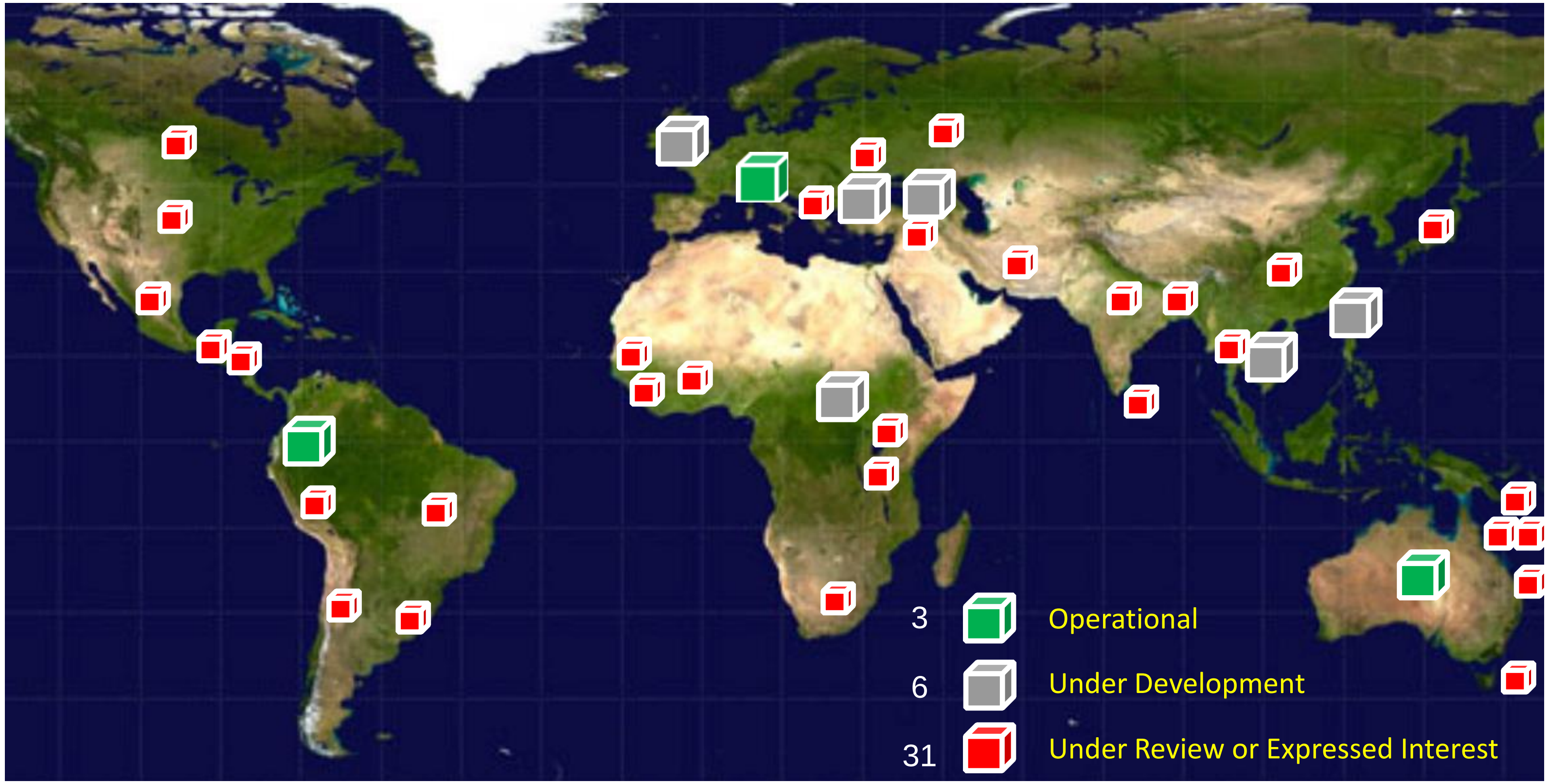
Tamar River, Tas.



Tweed River Bypass Project

Detection of change based on remedial actions

Open Data Cube International



Open Data Cube community

OPEN DATA CUBE
www.opendatacube.org

ODC vision

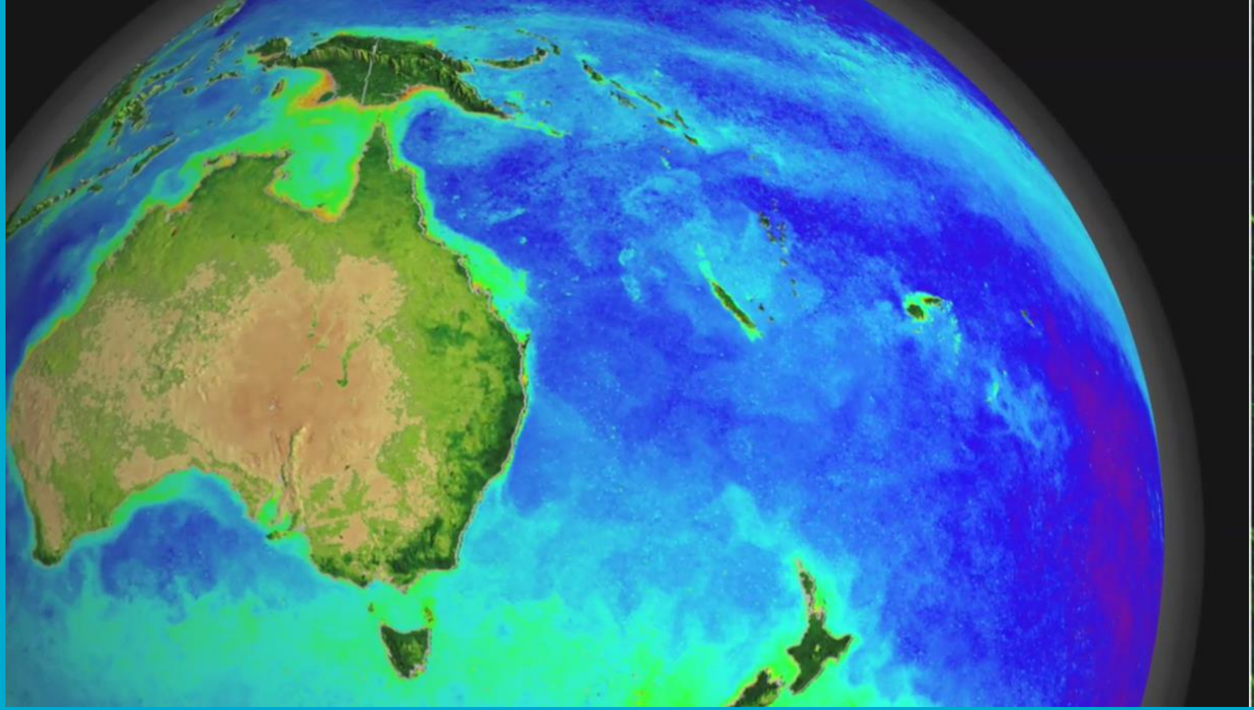
- Increase the impact and value of satellite data
- Provide a free and open EO data analysis architecture and tools
- Foster a community to grow the technology and applications

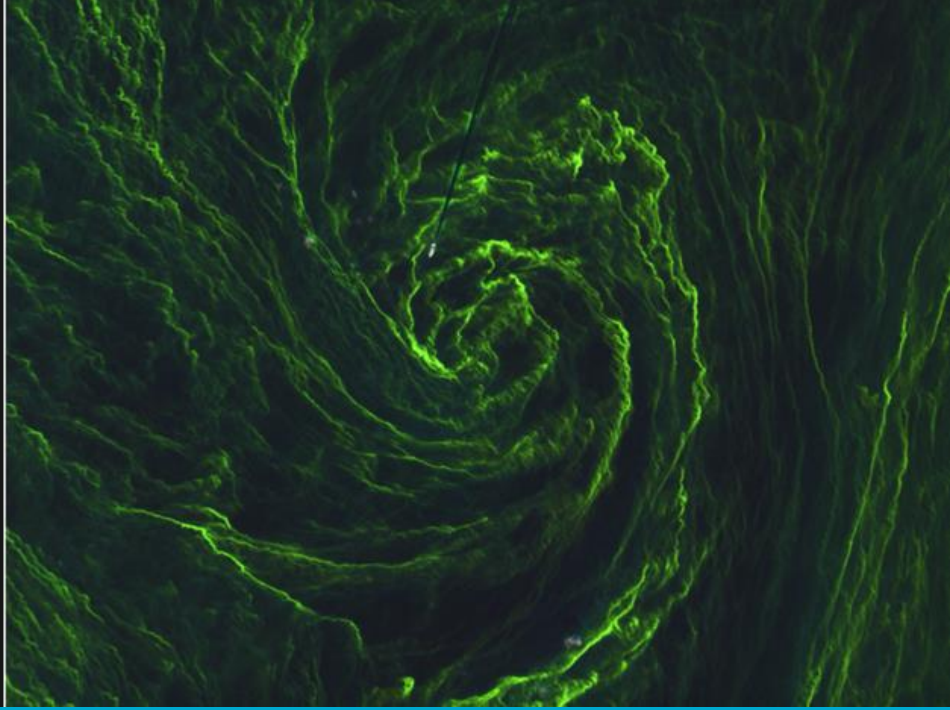
Growing list of Partners and Associates

- NASA (CEOS SEO), GA, CSIRO, USGS, IDEAM, VNSC, UK Catapult, RHEA, Swiss Met., NSPO, RADI, NZ Space, …

..and Initiatives

- CEOS DC, AfricaDataCube, Digital Earth Aust., CSIRO Earth Analytics Hub, Colombia DC, Vietnam DC, Swiss DC, …

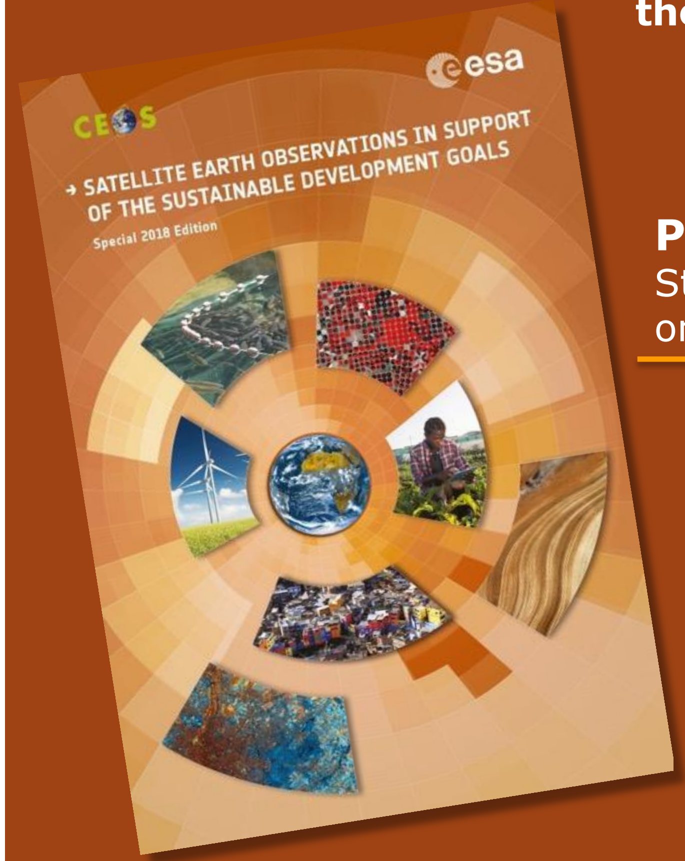




Earth Observation’s Role in Sustainable Development Goals: relevant Geospatial assessments of Freshwater, Estuaries, Coasts and Oceans.

ARNOLD DEKKER, FLORA KERBLAT, ANDY STEVEN, ALEX HELD
www.csiro.au

CEOS EO Handbook on SDGs



Part I
role of EO data in support to the SDGs

Part II
Stakeholders' perspectives on EO for the SDGs

Part III
Examples of EO contribution to SDG Targets and Indicators

Part II: Perspectives on EO for the SDGs

The Global Sustainable Development Goals

MDGs (2000-2015)		SDGs (2015-2030)
Developing country focused	→	Universal
Social	→	Social, Economic, and Environmental
Foreign Aid	→	Domestic Investment, Private Flows, and Aid
Official Statistics and Administrative Data	→	Big Data, Citizen Generated Data, Geospatial and Earth Observation Data, Open Data, and more

Source: Aditya Agrawal October 2016

GLOBAL PARTNERSHIP
FOR SUSTAINABLE DEVELOPMENT DATA

- 17 Goals, 169 Targets, 230 Indicators = Huge Data Needs

GLOBAL PARTNERSHIP
FOR SUSTAINABLE DEVELOPMENT DATA

Source: GEO "Supporting Official Statistics in Monitoring the SDGs", March 2016

GEO=Group on Earth Observations

SUSTAINABLE DEVELOPMENT GOALS	Population distribution	Cities and infrastructure mapping	Elevation and topography	Land cover and use mapping	Oceanographic observations	Hydrological and water quality observations	Atmospheric and air quality monitoring	Biodiversity and ecosystem observations	Agricultural Monitoring	Hazards, disasters and environmental impact monitoring
1 No poverty	X	X		X					X	
2 Zero hunger	X	X	X	X	X	X	X	X	X	X
3 Good health and well-being	X	X		X		X	X		X	X
4 Quality education	X	X								
5 Gender equality	X	X								
6 Clean water and sanitation	X	X	X	X	X	X		X	X	X
7 Afordable and clean energy	X	X	X	X	X	X	X	X		X
8 Decent work and economic growth	X	X	X	X					X	
9 Industry, innovation and infrastructure	X	X	X	X			X			X
10 Reduced inequalities	X	X								
11 Sustainable cities and communities	X	X	X	X			X	X	X	X
12 Responsible consumption and production	X	X	X	X				X		X
13 Climate action	X	X	X	X	X	X	X	X	X	X
14 Life below water	X	X	X	X	X	X		X	X	X
15 Life on land	X	X	X	X		X	X	X	X	X
16 Peace, justice and strong institutions	X	X		X						
17 Partnerships for the goals	X	X	X	X	X	X	X	X	X	X

Earth Observation & Geo-spatial information resources: SDG 6, 14 and 15 for SDG monitoring (GEO matrix)

SUSTAINABLE DEVELOPMENT GOALS

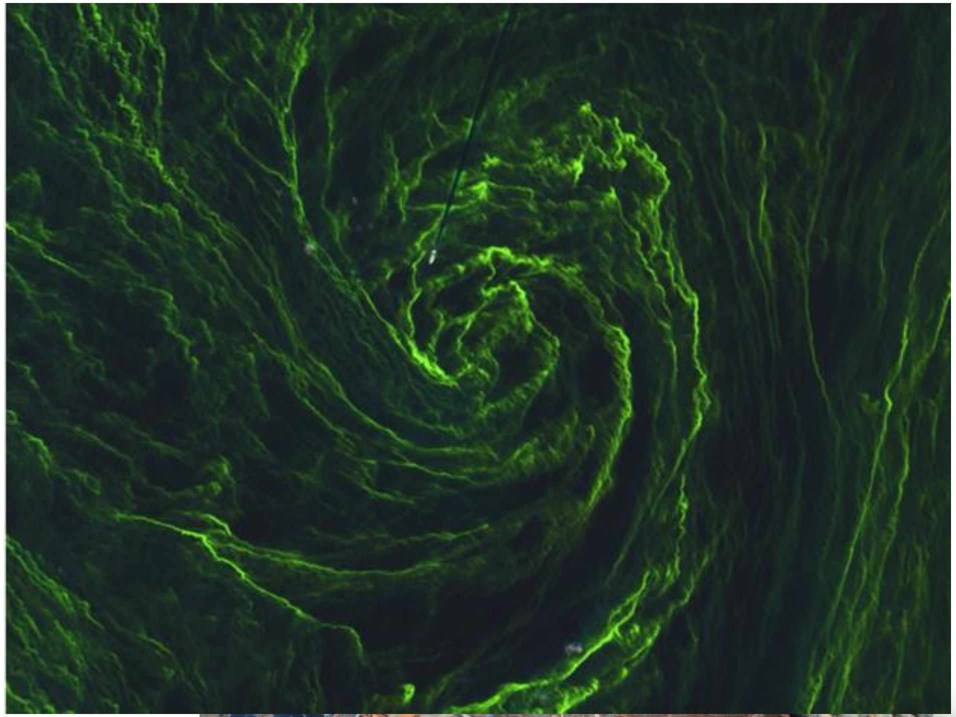
	Population distribution	Cities and infrastructure mapping	Elevation and topography	Land cover and use mapping	Oceanographic observations	Hydrological and water quality observations	Atmospheric and air quality monitoring	Biodiversity and ecosystem observations	Agricultural Monitoring	Hazards, disasters and environmental impact monitoring
6 Clean water and sanitation										
14 Life below water										
15 Life on land										

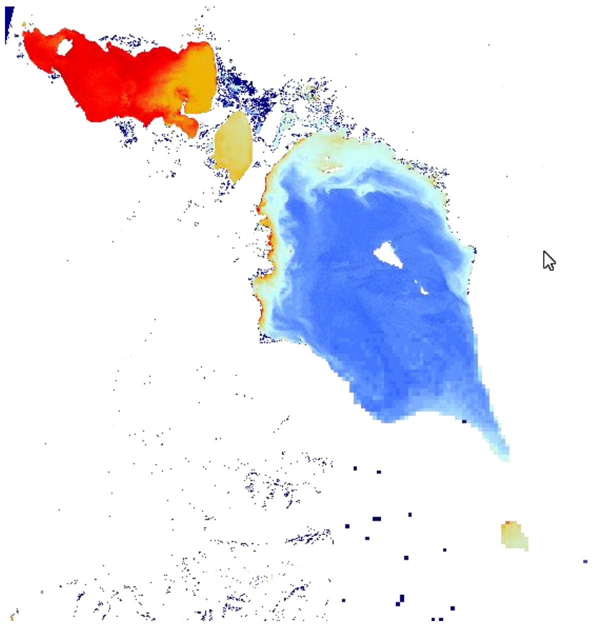
CSIRO

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Target	Indicator
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of wastewater safely treated 6.3.2 Proportion of bodies of water with good ambient water quality
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time

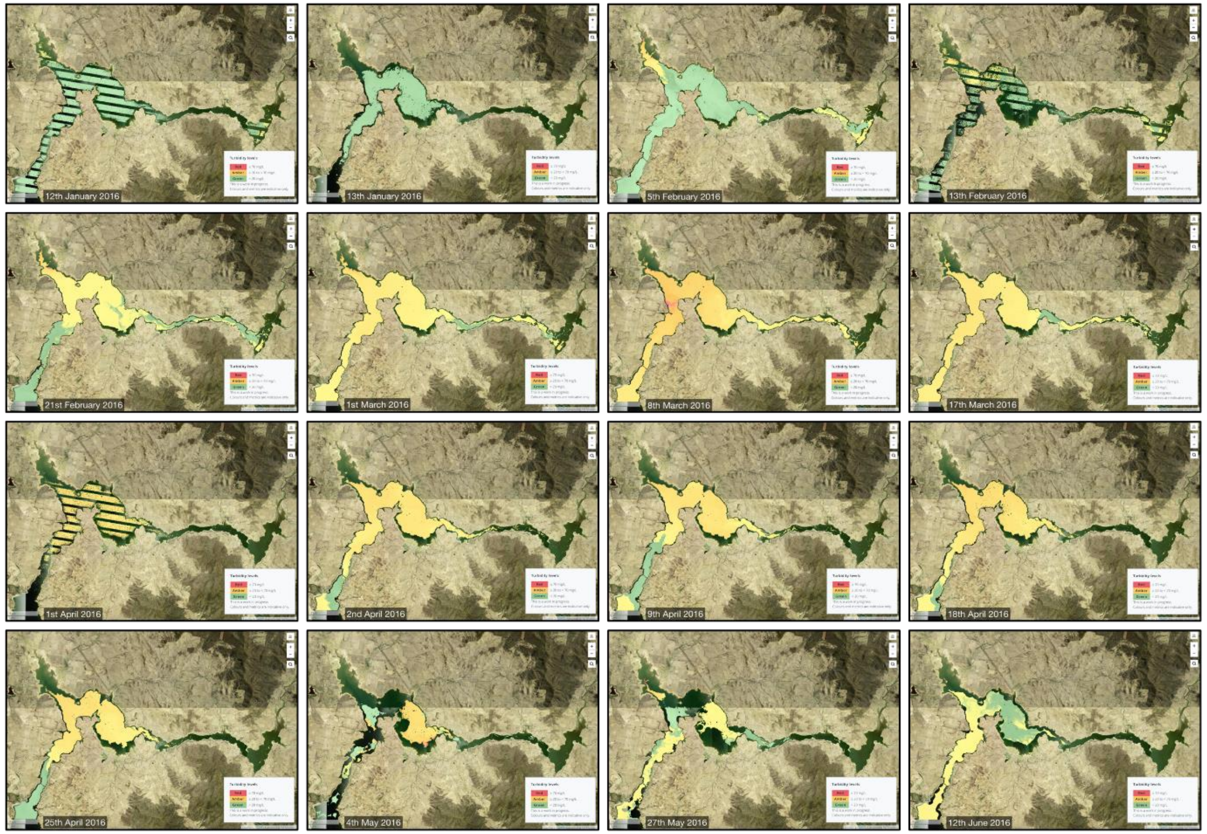
Examples of space-based images of algal blooms





Images courtesy of ESA, Brockman consulting, Steve Greb; Mark Matthews

Algal Bloom Early Warning Alert System NSW (web-based)



Time series of Landsat turbidity images for Lake Hume covering the summer to autumn period mid-January to mid-June 2016. The time series shows the development of an algal bloom from late February through March and April. This bloom provided the 'seed' to stimulate a bloom in the River Murray downstream of the reservoir which affected some ~1600 km of river for three months to June 2016. (**Source CSIRO and New South Wales Department of Primary Industries - Algal Management, Water).**

Example : Ambient Water Quality: SDG Indicators can evolve over time:

- SDG 6.3 indicator: P and N concentrations as a measure of eutrophication.
- We proposed that this will be hard to measure in over 10’s millions water bodies across their length and width globally.
- Another indicator of eutrophication can be increased turbidity due to phytoplankton growth and in hypertrophic circumstances algal blooms (other indicators exist too around macrophytes etc.)
- Turbidity, Secchi Disk Transparency, Vertical Attenuation of Light, Total Suspended Matter, Coloured Dissolved Organic Matter and Chlorophyll and Cyanobacterial pigment concentrations can already be measured from space.==========➔ logical solution for assessing ambient water quality!

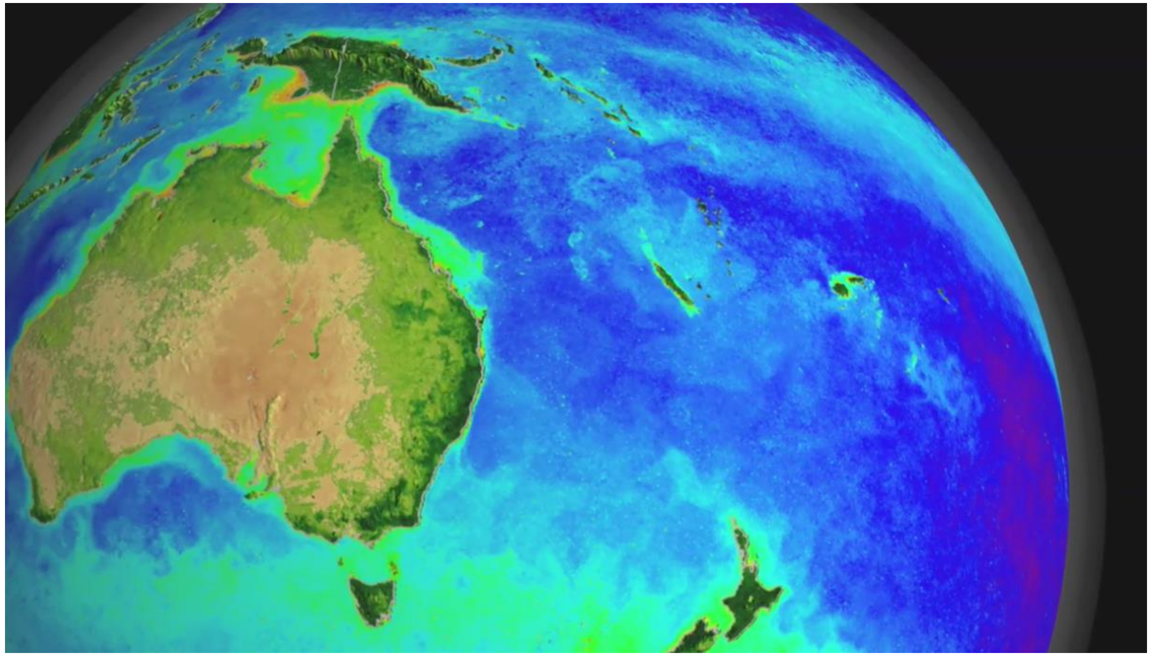
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Target

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

Indicator

14.1.1 Index of coastal eutrophication and floating plastic debris density



Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Target	Indicator
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type

Summary:

1) Retrospective processing capability that earth observation provides for archival earth observation data (back to 1984 for Landsat)
2) Physics-based earth observation methods reduce or eliminate the need for repetitive in situ measurements & automation ready
3) EO can provide near real time emergency information
4) (Some) national and several global systematic EO-based mapping systems are being built and the information will be publicly available
5) EO Sensors and information extraction methods are improving continuously
6) Funding insecurity (boom to bust) hampers effective resourcing of building the required infrastructure
7) Concerted long term action required
8) Validation of (multiple-source) national and global products will be essential

Vragen en discussie welkom!

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